

TOPIC 17 – EQUILIBRIUM

17.2: THE EQUILIBRIUM LAW IN FURTHER PRACTICE

IB Chemistry
T17D05



17.2 Equilibrium Law - 2 hours

- 17.2.1 Solve homogeneous equilibrium problems using the expression for K_c . (3)
- Just as discussed in Topic 07, the equilibrium constant for a reaction can be derived using the chemical equation and coefficients within.
- For the dynamic equilibrium of the decomposition of phosphorous pentachloride, the value for K_c is:
 - $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$



The value of K_c indicates the position of equilibrium

17.2 – Homogeneous Equilibria Calcs

- All equilibrium examples in IB Chemistry will be of a homogeneous nature for simplicity
- You must be able to
 - Confidently write equilibrium expressions
 - Put numbers to the process (use data to solve for K_c , etc)



17.1 – Example #1

- Nitrogen (II) oxide, NO, is a pollutant released into the atmosphere from car exhausts. It is also formed when nitrosyl chloride, NOCl, dissociates according to the following equation:
 - $2\text{NOCl(g)} \rightleftharpoons 2\text{NO(g)} + \text{Cl}_2\text{(g)}$
- Different amounts of each of the reactants were studied at two different temperatures, 503K and 738K.




	Concentration (mol cm ⁻³)		
Temperature (K)	NOCl	NO	Cl ₂
503	2.33x10 ⁻³	1.46x10 ⁻³	1.15x10 ⁻²
738	3.68x10 ⁻⁴	7.63x10 ⁻³	2.14x10 ⁻⁴

- A: write the expression for K_c
 B: Calculate K_c for both temps given

C: Is the forward reaction endo- or exo-thermic? Base it on Topic 7 ideas



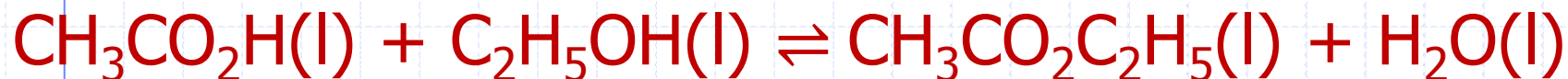
Example #1 - answers

- 
- At 503K
 - 
- At 738K
 - 
- Endothermic: The value of K_c is greater at 738K; K_c increases with temperature, with the forward reaction being favored to increase the proportion of products in the equilibrium mixture.



7.2 – Example #2

- The acid-catalyzed hydrolysis of ethyl ethanoate can be achieved by mixing the ester with dilute hydrochloric acid H^+



- If 1.00 mol of both ethyl ethanoate and water are mixed, in dynamic equilibrium 0.30 moles of ethanoic acid is found in the mixture
- Calculate K_c at this temperature



17.2 – Example #2 - answers

- First set up the equation as follows:

$$\text{CH}_3\text{CO}_2\text{H}(\text{l}) + \text{C}_2\text{H}_5\text{OH}(\text{l}) \rightleftharpoons \text{CH}_3\text{CO}_2\text{C}_2\text{H}_5(\text{l}) + \text{H}_2\text{O}(\text{l})$$

Starting amount (mol)	1.00	1.00	0.00	0.00
Equilibrium amount (mol)				0.30

- In taking into account the coefficients of the equation:

Starting amount (mol)	1.00	1.00	0.00	0.00
Equilibrium amount (mol)	(1.00-0.30)	(1.00-0.30)	0.30	0.30

- In order to put these amount in the equilibrium expression to find K_c , they must be values of molarity (mol cm^{-3}) and not just moles (mol)

Equil. Conc. (mol dm^{-3})	0.70/V	0.70/V	0.30/V	0.30/V
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$$K_c = \frac{[\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5][\text{H}_2\text{O}]}{[\text{CH}_3\text{CO}_2\text{H}][\text{C}_2\text{H}_5\text{OH}]}$$



17.2 – Example #3

- An organic compound X exists in equilibrium with its isomer, Y, in the liquid state at a particular temperature
 - $X(l) \rightleftharpoons Y(l)$
- Calculate how many moles of Y are formed at equilibrium if 1 mole of X is allowed to reach equilibrium at this temperature, if K_c has a value of 0.02



17.2 – Example #3 - answers

- Let the number of moles of Y at equilibrium = y moles

	X(l)	\rightleftharpoons	Y(l)
Starting amount (mol)	1.00		0.00
Equilibrium amount (mol)	(1.00-y)		y
Equil. Conc. (mol dm ⁻³)	(1.00-y)/V		y/V

- The K_c value, which is given as 0.02, can be set equal to the expression:

- In the expression, the concentration (or # mol) can be calculated for y.
()



17.4 – Example #4

- Phosphorous (V) chloride undergoes thermal decomposition as follows
 - $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
- The equilibrium expression is as follows:
 - _____
- Some PCl_5 was placed in an evacuated flask of volume 1.0 dm^3 at 500K .
- An equilibrium was then established in which the concentration of PCl_5 was $4.0 \times 10^{-2} \text{ mol dm}^{-3}$.
- The value of K_c for the reaction at 500K is 1.00×10^{-2} .
- Calculate the concentration of chlorine in the equilibrium mixture



17.4 – Example #4 - answers

- Let the concentration of Cl_2 at equilibrium = $x \text{ mol dm}^{-3}$



To solve for the moles of x , set up the equilibrium expression:

Solve for x , and find:

